ORIGINAL

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON DC 20554

In The Matter of	)	
	)	
Section 68.4(a) of the Commission's Rules	)	RM-8658
Hearing Aid-Compatible Telephones	)	

Comments of QUALCOMM Incorporated

1. QUALCOMM Incorporated ("QUALCOMM") hereby submits its Comments concerning the above captioned Petition for Rule Making filed by Helping Equalize Access Rights in Telecommunications NOW or HEAR-IT NOW[1] on June 5, 1995.[2] In its Petition, HEAR-IT NOW asked the Commission to initiate a Rule Making Proceeding, "to amend Section 68.4(a) of the Commission's Rules, 47 C.F.R. § 68.4(a), to specify that broadband PCS devices capable of voice transmission or reception must be hearing aid-compatible."[3]

BACKGROUND

2. In 1988, Congress passed the Hearing Aid Compatibility Act of 1988 ("the Act"). The Act requires that the Commission, "shall require that ... all telephones ... provide internal means for

[1] HEAR-IT NOW identifies itself as "a coalition of groups formed to promote equal access by the Nation's four million hearing aid wearers to advanced communications services." It reports that its members "include Self-Help for Hard of Hearing People, Inc., the Alexander Graham Bell Association for the Deaf and the Wireless Communications Council." HEAR IT-NOW Petition for Rule Making, RM-8568, 1, N.1 (June 5, 1995) (Hereinafter "Petition")

[2] The Commission placed the Petition on Public Notice on June 15, 1995.

[3] Petition, 1.

effective use with hearing aids that are designed to be compatible with telephones which meet established technical standards for hearing aid compatibility."[4] However, the next section of the Act provides that, "The initial regulations prescribed by the Commission ... shall exempt from the requirements established pursuant to paragraph (1) (B) ... telephones used with public mobile radio services ... ."[5]

3. The Act also requires that, "The Commission shall periodically assess the appropriateness of continuing in effect the exemptions provided for telephones used with public mobile services ... " and that it, "shall revoke or otherwise limit any such exemption if the Commission determines that --

(i) such revocation or limitation is in the public interest;

(ii) continuation of the exemption without such revocation or limitation would have an adverse effect on hearing-impaired individuals;

(iii) compliance with the requirements of paragraph (1)(B) is technologically feasible for the telephones to which the exemption applies; and

(iv) compliance with the requirements of paragraph (1)(B) would not increase costs to such an extent that the telephones to which the exemptions applies could not be successfully marketed."[6]

4. HEAR-IT NOW argues that, "A limited revocation of the Act's exemptions for private radio services or public mobile services, insofar as PCS devices fall within the those categories,

[4] 47 U. S. C. 610 (b)(1)(B).

[5] 47 U. S. C. 610 (b)(2)(A).

6 47 U. S. C. 610 (b)(2)(C).

is warranted under the four guidelines set forth in the Act for the elimination of such exemptions."[7] Regarding the third guideline, HEAR-IT NOW argues that, "compliance with existing hearing aid compatibility regulations is technologically feasible."[8]

QUALCOMM's Interest

5. QUALCOMM developed the code division multiple access (CDMA) technology that is the basis for one of the standards for broadband PCS, ANSI J-STD-008, "Personal Station-Base Station Compatibility Requirements for 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Communications Systems". QUALCOMM manufactures both CDMA infrastructure equipment and subscriber units for broadband PCS.[9] A number of PCS licensees and potential licensees have indicated that they will use this standard to implement their systems.

6. Over the past several years QUALCOMM has conducted a number of tests at both 800 MHz and 1.8 GHz to determine the interaction between its CDMA technology and a number of different hearing aids. QUALCOMM also has tested the interaction between GSM technology and the same set of hearing aids.

7. QUALCOMM's tests show several things; among them are:

• The most significant factor in determining the degree of interference to hearing aids and other susceptible electronic

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7 Petition at 5 (footnote omitted).

8 *Id.*, at 7.

9 QUALCOMM Personal Electronics, a joint venture of QUALCOMM and Sony Corporation, will manufacture QUALCOMM's mobiles.

equipment is the peak transmitter power, not average power, of the portable telephone;

• Hearing aid wearers can make CDMA calls, using both 800 and 1800 MHz units, with no objectionable interference in most parts of a well-designed CDMA system. In the unlikely event that the wearers experience minor interference in isolated areas of such a system, the "full rate constrained" option that QUALCOMM and other manufacturers are making available[10] alleviates the problem;

• Most hearing aid users cannot make a telephone call with the hearing aid assisted ear using a GSM portable operating at any feasible power level. This result is consistent with the extensive body of literature from around the world that QUALCOMM has reviewed as part of its research in this area. Attachment A is a report of QUALCOMM's test results.

Respectfully submitted,

QUALCOMM Incorporated

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July 17, 1995

[10] The CDMA Development Group is establishing a service option that will command a CDMA phone to operate in the full-rate mode whenever the transmit power exceeds some predetermined level, such as 50 mWatts. In this mode, the transmitter does not switch on and off. Forcing a CDMA phone to operate in fixed full-rate-rate mode eliminates any potential interference. This service option would be made available to hearing aid wearers upon request.

Attachment A

Measurement of RF Interference by CDMA and GSM Digital Cellular Portable Telephones on Hearing Aids

Eber F. Lambert

July 6, 1995

INTRODUCTION

Since late 1993 QUALCOMM has performed a series of tests to assess the nature and extent of audible interference to hearing aids caused by CDMA and GSM digital cellular signals. These tests clearly show the following: First, the most significant factor in determining the degree of interference in hearing aids and other susceptible electronics is the peak transmit power, not average power, of the portable telephone. All other conditions made equal, GSM telephones will transmit at a peak power at least 10 to 17dB (or 10 to 50 times) greater than CDMA phones thus creating far more severe interference. Second, it is very unlikely that any hearing aid user could make a telephone call using a GSM portable with a hearing aid assisted ear. This result is consistent with the findings contained in other test reports from Australia, New Zealand and Denmark that QUALCOMM has reviewed as part of its research in this area. QUALCOMM's tests further show that it is very likely that a hearing aid user could use a "full rate constrained" CDMA portable with the hearing aid assisted ear with no problem or complaint.

Many hearing aids act as peak power detectors of amplitude modulated (AM) radio signals. They also contain high gain audio amplifiers. As a result they may experience significant interference when they are operated in the presence of radio signals with significant AM content. The frequency modulated (FM) radio signals used by today's analog cellular system do not cause any significant interference to hearing aids.

GSM uses time division multiple access (TDMA) technology to share the spectrum among multiple users. The primary characteristic of this technology is the need to rapidly turn the RF transmission on and off ("gating") at a fixed rated so multiple users can use a single channel. This results in a waveform that is 100% amplitude modulated at a rate of approximately 217 Hz. It is this 217 Hz signal and its harmonics that, once detected, become the audible interference in hearing aids.

QUALCOMM's code division multiple access CDMA can also produce amplitude modulation of the transmitted signal. Because the vocoder operates in a variable rate mode, the CDMA waveform is gated on and off in a pseudo-random manner. The number of pulses transmitted is a function of the activity of the variable rate vocoder. The vocoder rate varies as a function of voice activity and system parameters, hence not only does the relative position in time of bursts vary randomly, but the number of bursts per unit time varies as well. The net effect of this, when the composite CDMA signal is passed through an AM detector, is an audio output that is spectrally spread rather than a single or set of harmonically related tones that one would observe for a periodically gated RF signal of fixed duty cycle such as the GSM TDMA signal. In essence a "crackling" or "static" noise in the case of CDMA versus the "constant buzz" of the detected GSM TDMA signal.

CDMA could be operated in a "full rate constrained" mode for selected phones when transmitting above a certain power level. This would eliminate the on-off gating of the

portable transmitter and the potential for interference associated with the AM content. The detected noise caused by this mode is essentially white noise with some noticeable interference associated with small pseudo-random changes in power control. This noise is difficult to discern from the normal background noise of the hearing aid.

Again, the most important factor in determining whether a particular AM signal will cause detectable interference to a hearing aid is the peak transmitted power. Therefore to make a meaningful comparison of interference, both the GSM signal and CDMA phone were operated at relative signal levels which arise from comparable use. In practice, the transmit signal levels of both GSM and CDMA are constantly changing in response to characteristics of the radio channel. However, in normal conditions, CDMA phones transmit at power levels approximately 10 to 17 dB lower than power levels of GSM phones under the same conditions. In these tests QUALCOMM used a conservative 10dB difference. QUALCOMM performed one set of tests at 800 MHz with a simulated GSM signal at a normal GSM phone operating level (2W peak, 217 Hz burst rate, 1/8 duty cycle) and the CDMA phone operating at a maximum operating level (200mW peak). QUALCOMM performed a second set of tests at 1900 MHz using CDMA power levels of 20 milliwatts and 200 milliwatts and a GSM power level of 1Watt. At 200 milliwatts, the CDMA tests were performed in both the variable rate and full rate constrained modes.

LISTENING TESTS

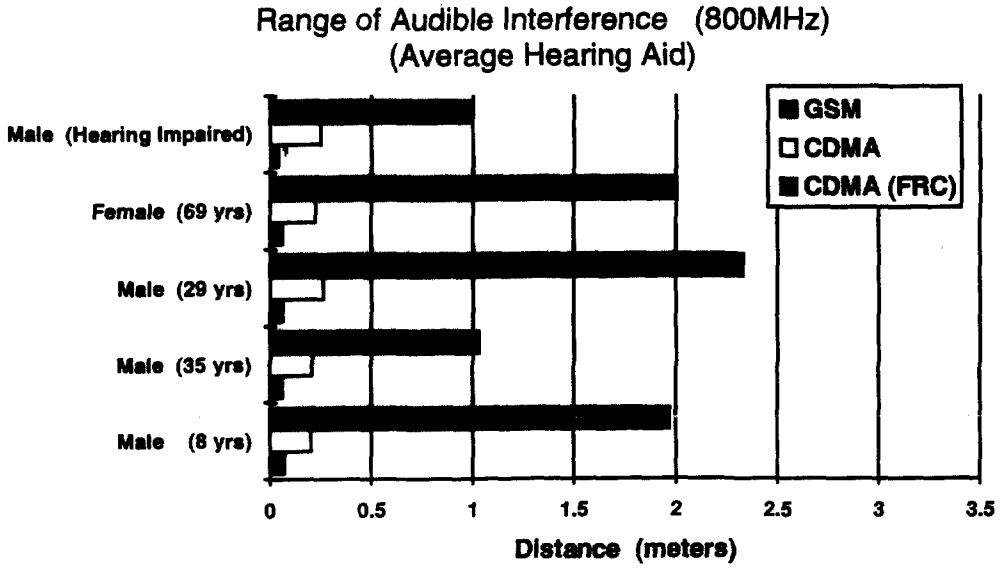
Listening tests were performed on two adult males (30 and 35 years old), a 69-year old female and 8-year old male, all with normal hearing. A sample of 6 different hearing aids from three different manufacturers was tested. Styles used included Behind-Ear, In-Ear and In-Ear canal style hearing aids. This sample represents a cross section of commonly used hearing aids currently available through audiologists. The test set up used the same power amplifier and radiating antenna for both waveforms. The CDMA signal was derived from QUALCOMM's CD-7000 CDMA Digital Portable Phone with closed loop power control deactivated while the GSM TDMA signal was simulated by AM modulating an RF signal generator.

The results show that interference from a CDMA 800 MHz portable transmission could not be detected until the radiating element was within 0.5 meters of the hearing aid while operating at maximum peak transmit power. When transmit power was reduced by 10dB (to 20mW peak), representing the typical operating peak power level for a CDMA portable, this distance dropped to less than 0.12m (~ 5in). When operating at a maximum power (200mW) in a "full rate constrained" mode, the worst case detectable distance dropped to less than 0.1m (~ 4in). Hence, with a phone in the normal listening position with antenna extended, it is unlikely interference would be detected.

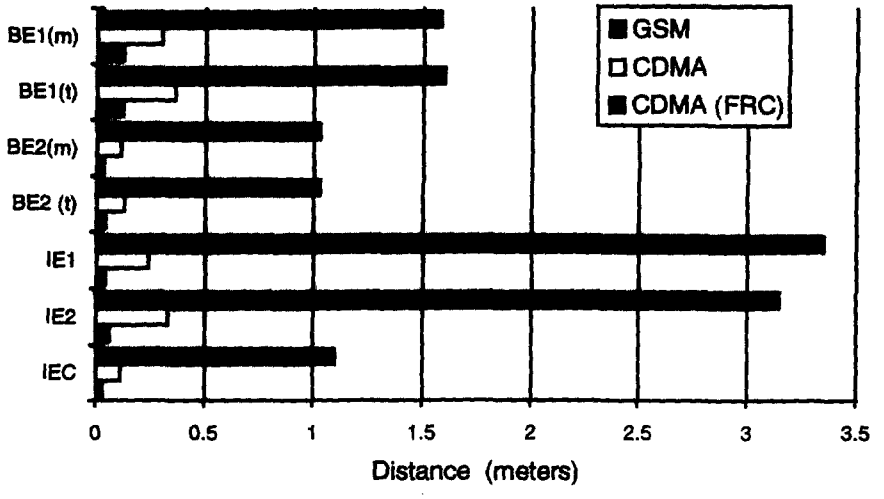
Conversely, the GSM TDMA signal caused audible interference when the radiating element was within 1 to 3.5 meters (~ 3 to 12 feet) of the hearing aid under test. When

the GSM transmit power was reduced by 10dB (to 200mW peak), a minimum possible peak transmit power of a GSM telephone in a system where power control is used the distance at which interference occurred was greater than twice that at which interference could be detected from a CDMA phone operating at its maximum transmit power. This indicates that the "constant buzz" of the detected GSM interference is more readily noticeable and possibly more objectionable than the "static" noise of detected CDMA transmissions. Due to the different nature of the sound, for an equal volume of audio interference, CDMA would, in fact, have to transmit at significantly higher peak power than GSM.

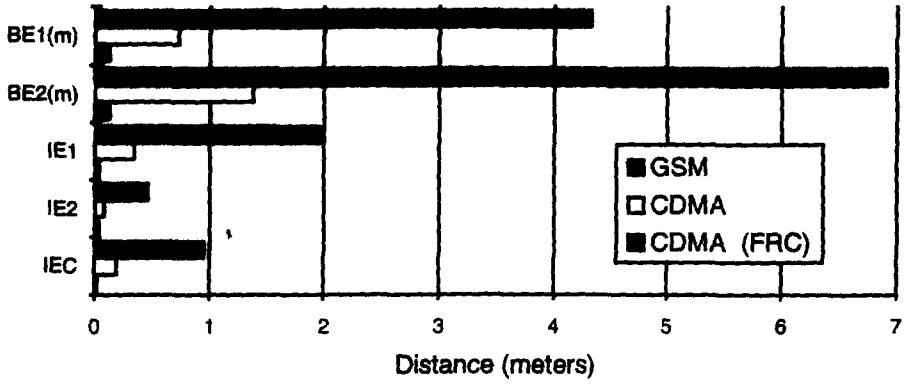
As expected this experimental data varied with listener and hearing aid under test. The following charts represent the data for each listener averaged over the sample of hearing aids tested and the data for each hearing aid averaged over the listeners respectively. Data for the hearing impaired individual was added for comparison and not used to calculate any of the averages. CDMA (FRC) indicates a "full rate constrained" CDMA signal at 200mW. The GSM and CDMA entries are for the comparable worst case peak transmit power levels.



Range of Audible Interference (800MHz)
(Average Listener)



Range of Audible Interference (1900 MHz)
(Average Listener)



The above graph shows the data obtained for the average listener at 1900MHz. The conditions for this test are the same as 800MHz except that the GSM signal has been lowered to a specified 1W peak power per DCS-1900 and a different radiating element was used. One can see that the Behind-Ear style hearing aids in this case are much more sensitive to interference at 1900MHz while the In-ear type are somewhat less sensitive. This again may vary with hearing aid types and hearing aid users. One can conclude that peak transmit power is still much more significant than channel frequency or UHF band in determining the severity of interference of this type. When the CDMA signal level was dropped to a typical 20mW peak transmit power level at 1900MHz, the distance at which interference was detected less than 0.3 m (~12in , worst case).

For a single listener , a set of measurements *was* made to determine at what power level the CDMA signal became audible for each hearing aid with the radiating antenna 2 cm from the hearing aid and adjusted vertically to give the maximum level of interference (found to be approximately the center of the radiating antenna). Results were as follows:

BE1 (m)	BE1 (t)	BE2 (m)	BE2 (t)	IE1	IE2	IEC
3.6 dBm (2.3 mW)	-0.5 dBm (0.9mW)	8.0 dBm (6.3mW)	-1.6 dBm (0.7mW)	-3.3 dBm (0.5mW)	0.7 dBm (1.2mW)	1.5 dBm (1.4mW)

To validate the results of the laboratory testing, a hearing impaired adult male volunteer was tested under the worst case conditions at 800MHz using his hardware (Phonak PE 845). The results were as follows :

Hearing Impaired Listener	CDMA @ 200 mW	GSM @ 2W
Distance at which interference detected	25 cm	100 cm
Distance interference became "annoying"	8 cm	65 cm

The listener was unable to detect interference when CDMA was full rate constrained.

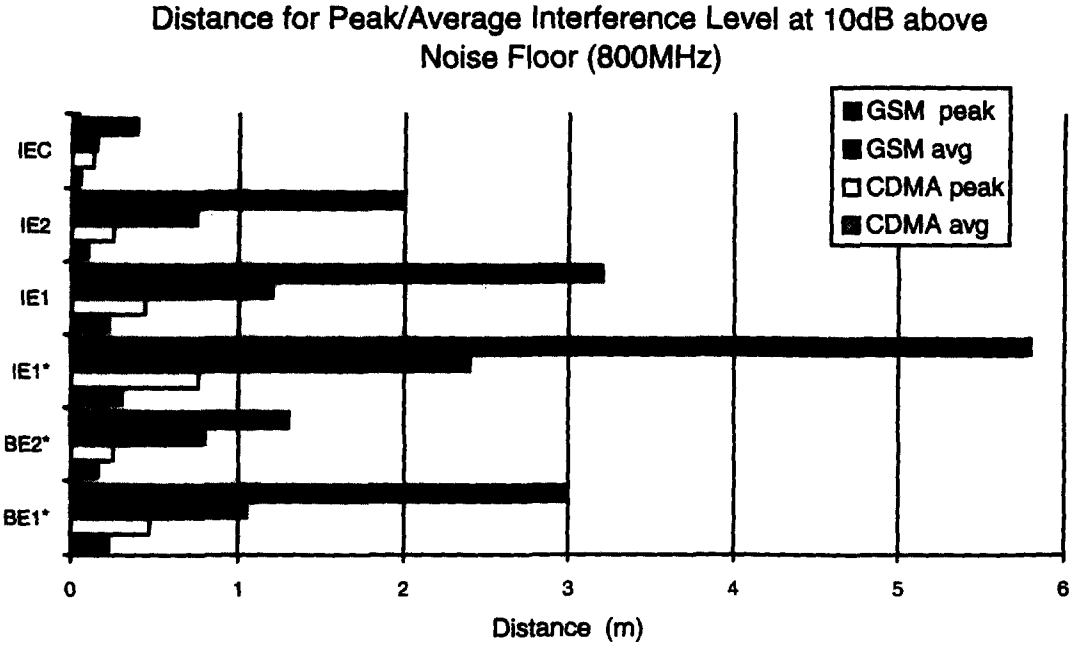
The results indicate that the relative findings of the listening tests are valid. One might further conclude that placing a hearing aid in or on the ear would reduce its sensitivity to RF interference by attenuating or distorting the incident field such that closer proximity to the radiating element or greater transmit power would be required to achieve the same level of audible interference.

To further evaluate the difference between these laboratory measurements and actual hearing aid users, a small group of six hearing aid users was tested using an 800MHz CDMA test phone transmitting at fixed 200mW. None of the six were able to hear interference when the phone was full rate constrained. Three were able to notice some interference in variable rate but indicated that its was not objectionable. One user, when utilizing a telecoil and high gain hearing aid found the variable rate objectionable in this case. He also was detecting the phones processor EMI and indicated he could not use his telecoil mode around most electronic equipment such as his computer without significant interference.

SPECTRAL ANALYSIS TESTS

In order to evaluate the subjectivity of listening tests, a set of measurements was tabulated for each hearing aid and hearing aid mode for the distance at which the audio power level and peak audio level of the induced interference was measured to be 10dB above the hearing aid/room noise floor. The hearing aids with AGC were measured with the microphone input obstructed. The PEAK measurement is the distance at which any spectral component within the 100Hz to 3kHz band exceeds 10dB above the noise floor. The AVERAGE measurement is the distance at which the integrated interference power

in the 100Hz-10kHz band exceeds 10dB above the noise floor (see Figure 3). Data for the tele-coil (t) mode of the BE hearing aids was omitted due to the high average noise floor the hearing aid exhibits in this mode. As indicated below, the distance at which an equivalent interference level is measured is significantly larger for GSM than CDMA. Furthermore, these relative measurements correlate well with the results of the averaged listening test data.



* indicates microphone,was obstructed to produce lower audio noise floor and highest audio gain in models with Automatic Gain Control

CONCLUSION:

The tests performed show that a CDMA portable is far less likely to cause objectionable interference to a hearing aid than a GSM portable when both are operating at specified maximum peak transmit power levels. The range at which the interference occurs was found to primarily be a function of peak transmit power. A CDMA portable operating at maximum peak transmit power (200mW) produces no audible interference until located within 0.5 meters of various hearing aids. In normal operation, where all CDMA phones are subject to system power control, transmit power levels vary, averaging 10 to 20 mW of peak output power. Measurements made at 20mW indicate the radiating antenna must be within 2 to 13cm (1 to 5 inches) for audible interference to be detected in hearing aids. Furthermore, by employing a "full rate constrained" mode of operation, CDMA phones could be used by hearing aid users with little if any noticeable interference when operating near maximum peak power.

Conversely, a GSM TDMA portable in normal operation transmits at a nominal peak power level of 2 watts (1 watt at 1900MHz). Tests showed that a GSM portable when located within a distance of 1 to 3.5 meters from a hearing aid would cause audible interference. Consequently, it would be extremely unlikely that a GSM phone could be used by a hearing aid user, nor in the near vacinity of a hearing aid user without causing objectionable interference.

CERTIFICATE OF SERVICE

I, Karen A. Laake, hereby certify that a copy of the forgoing Comments of QUALCOMM Incorporated was served via first-class, postage prepaid mail, this 17th day of July, 1995, to:

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Council to HEAR-IT-NOW

Karen A. Laake
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